Remarks

Claims 1, 2, 8, 13, 14, 20, 21 and 25-32 are pending herein.

In the Office Action, claims 13, 14, 20-25 and 30-32 are rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent Application Publication No. 2001/0000415 to Ross; and claims 1, 2, 8, 9 and 26-29 are rejected under §103(a) as being unpatentable over U.S. Patent Application Publication No. 2002/0123240 to Gallagher et al. ("Gallagher") in view of Ross and U.S. Patent No. 6,420,088 to Angelopoulos et al. ("Angelopoulos").

In view of the remarks herein, Applicants respectfully request reconsideration and withdrawal of the rejections set forth in the Office Action.

I. Rejection of Claims 13, 14, 20-25 and 30-32

Claims 13, 14, 20-25 and 30-32 are rejected under §103(a) as being unpatentable over Ross.

Applicants respectfully submit that claims 13, 14, 20, 21, 25 and 30-32 would not have been obvious over Ross. Claims 22-24 were previously canceled.

Claims 13 and 30 are independent. Claims 14, 20 and 21 depend directly or indirectly upon claim 13. Claims 31 and 32 depend upon claim 30. Claim 25 depends upon claim 1, which is also independent.

Claims 1 and 13 are both directed to a method of forming a polar liquid film on a surface of an organic film formed on a substrate in a processing vessel. Each method involves a "modifying step" and an "applying step". The modifying step involves curing the organic film and imparting an affinity for the polar liquid to the organic film by irradiating the organic film with electron beams by means of an electron-beam irradiation device in a rare gas atmosphere formed in the processing vessel. The applying step involves applying the polar liquid to the surface of the organic film processed by the modifying step.

In claims 1 and 13, the modifying step is divided into two individual sub-steps of:

> (i) curing the organic film by irradiating the organic film with the electron beams in the rare gas atmosphere of a first pressure in the processing vessel; and
>
> (ii) imparting the affinity for the polar liquid to the organic film by irradiating the organic film with the electron beams in the rare gas atmosphere of a second pressure higher than the first pressure in the processing vessel.

Claim 30 is also directed to a method of forming an inorganic film on a surface of an organic film formed on a substrate in a processing vessel. The method of claim 30 involves a "modifying step" and a "film forming step". The modifying step involves curing the organic film and imparting an affinity for the inorganic film to the organic film by irradiating the organic film with electron beams by means of an electron-beam irradiation device in a rare gas atmosphere formed in the processing vessel. The film forming step involves forming the inorganic film on the surface of the organic film processed by the modifying step.

The modifying step in claim 30 is divided into the following individual sub-steps:

> (i) curing the organic film entirely by irradiating the organic film with the electron beams with a first voltage applied to the electron-beam irradiation device, in the rare gas atmosphere of a first pressure in the processing vessel,
>
> (ii) further curing a surface of the organic film by irradiating the organic film with the electron beams with a second voltage lower than the first voltage applied to the electron-beam irradiation device, in the rare gas atmosphere of the first pressure in the processing vessel, and
>
> (iii) imparting the affinity for the inorganic film to the organic film by irradiating the organic film with the electron beams with the second voltage applied to the electron-beam irradiation device, in the rare gas atmosphere of a second pressure higher than the first pressure in the processing vessel.

Applicants submit that, in the modifying sub-steps recited in claims 1, 13 and 30, the variations in pressure and voltage values during the electron-beam irradiation process are not mere adjustments of parameters but are used to divide the respective modifying steps into individual effective sub-steps for their respective purposes.

According to the Office Action, the electron beam processing conditions recited in the claims are result effective variables. As support for this position, the Office Action cites page 11, lines 16-22, of the instant specification, which states that:

> In the foregoing description, it is supposed that the pressure of the rare gas atmosphere and the voltage applied to the electron-beam tubes 4 are fixed during the EB curing process for irradiating the SOD film 51 with the electron beams B. The pressure of the rare gas atmosphere and/or the voltage applied to the electron-beam tubes 4 may be changed during the EB curing process. [emphasis added]

Applicants submit that the above quoted passage should be considered with the specification's teaching at page 11, lines 2-15:

> If the pressure of the rare gas atmosphere is ***below 1 torr***, the electron beans tend to pass through the rare gas atmosphere without exerting significant effect on the rare gas atmosphere, i.e., without ionizing the rare gas. ***Consequently, the rare gas is not ionized properly and only the curing of the SOD film is advanced. If the pressure of the rare gas atmosphere is excessively high***, the frequency of collision between the electrons of the electron beams and the atoms of the rare gas increases. The collision between the electrons of the electron beams and the atoms of the rare gas attenuates the energy of the electron beams and thereby ***the intensity of the electron beams falling on the wafer W is decreased sharply. Consequently, the curing of the SOD film cannot be properly achieved***.

Applicants submit that the specification's teaching at page 11, lines 2-15 indicates the difficulty of finding a single pressure for the rare gas atmosphere that can both satisfactorily cure the SOD film and render the cured SOD film hydrophilic. At page 10, lines 7-20 (which is part of the "foregoing description" referred to in the above-quoted passage), the instant specification teaches that:

> ***Electrons of part of the electron beams B emitted by the electron-beam tubes 4 fall directly on the SOD film 51*** and activates an organic compound in a surface layer of the SOD film 51 by their energy. Consequently, a crosslinking reaction occurs in the surface layer and thereby the SOD film 51 is caused to shrink and ***cured***. ***Electrons of the rest of the electron beams B collide against and ionize the rare gas to produce a plasma.*** Consequently, radicals, ions and secondary electrons are generated. The ions and the secondary electrons react with the organic material in the vicinity of the surface of the SOD film 51 to reduce alkyl groups, such as methyl groups, and create an oxygen-rich atmosphere around the surface of the SOD film 51. ***This oxygen-rich atmosphere makes the surface of the SOD film 51 hydrophilic.*** [emphasis added]

Thus, the instant specification teaches the curing of the SOD film 51 is effected by the electrons of the electron beams B that fall directly on the SOD film 51, whereas the SOD film 51 is made hydrophilic as a result of the other electrons colliding against the rare gas and causing a plasma to form. This passage taken with the passage at page 11, lines 2-15, indicates that a particular pressure may achieve satisfactory curing of the SOD film but may not be sufficient to render the cured SOD film hydrophilic, and vice versa. As Applicants teach at page 11, lines 23-36:

> The EB curing process can be divided into a first stage for curing the SOD film and a second stage of making the SOD film hydrophilic by changing the pressure of the rare gas atmosphere during the EB curing process ***to ensure that the SOD film is cured and made hydrophilic satisfactorily.*** For example, the rare gas atmosphere is kept at a pressure not higher than 1 torr and the SOD film is irradiated with electron beams to cure the SOD film in an initial stage of the EB curing process, and then the rare gas atmosphere is increased to a pressure higher than 1 torr to promote the generation of radicals by ionizing the rare gas. Consequently, the radicals act on the surface of the SOD film to make the surface of the SOD film hydrophilic by cutting chemical bonds of hydrophobic groups, such as alkyl groups.

Thus, the instant specification teaches that the curing and hydrophilicity-rendering (i.e., affinity-imparting) steps are best satisfied at particular pressures which happen to differ from one another. Thus, it is preferred that the "modifying step" be divided into two sub-steps, i.e., curing and affinity-imparting.

The above discussion also applies to the voltages at which the curing and affinity-imparting sub-steps are conducted. The instant specification teaches at page 12, line 16 – page 13, line 12:

> For example, a second SOD film 62 as a protective film is formed as shown in FIG. 4(b) by applying an organic material to a surface of a first SOD film 61 shown in FIG. 4(a). Then, an EB curing process is performed to irradiate the SOD films 61 and 62 with electron beams B as shown in FIG. 4(c). ***In a first half stage of the EB curing process, a high voltage is applied to the electron-beam tubes 4 to make electron beam penetrate deep into the first SOD film 61.*** Consequently, the second SOD film 62 is cured entirely to form a protective film having a high mechanical strength. ***In a second half stage of the EB curing process, a low voltage is***

> ***applied to the electron-beam tubes 4 to promote reaction in the surface of the second SOD film 62.*** Consequently, hydrophobic groups, such as methyl groups, in the surface of the second SOD film 62 are decomposed. ***Consequently, the surface of the second SOD film 62 shrinks and the mechanical strength of the surface of the second SOD film 62 is further enhanced and the surface of the second SOD film 62 becomes hydrophilic.*** When the hydrophobic groups in the surface of the second SOD film 62 are thus decomposed, the molecular structure of the surface of the second SOD film 62 is modified and bears a closer resemblance to that of an inorganic film, and the affinity of the second SOD film 62 for an inorganic film can be enhanced. [emphasis added]
>
> The pressure of the rare gas atmosphere and the voltage applied to the electron-beam tubes 4 may be simultaneously changed or may be changed at different times, respectively. ***It is preferable to change the pressure of the rare gas atmosphere and the voltage applied to the electron-beam tubes 4 at different times, respectively, to distinguish the process for curing the film and the process for making the film hydrophilic from each other.*** It is preferable for high throughput to change the pressure of the rare gas atmosphere and the voltage applied to the electron-beam tubes 4 simultaneously. [emphasis added]

Thus, Applicants respectfully submit that, in view of the importance of the particular pressure and voltage values to whether satisfactory curing and affinity-imparting are achieved, the variations in pressure and voltage recited in the instant claims are not mere adjustments of parameters but are used to divide the respective modifying steps into individual effective sub-steps for their respective purposes, i.e., curing and affinity-imparting, respectively.

The Office Action acknowledges that Ross does not teach the pressure and voltage variations used in the modifying sub-steps recited in the claims. In Ross, the electron beam is used for (i) both of the curing and the surface treatment or (ii) only the surface treatment. In addition, the surface treatment in Ross does not involve a step of imparting affinity but rather a step of removing moisture, hydrogen, organic solvents and particles on or near the surface of the dielectric layer without modifying the material of the film itself.

Consequently, in view of the remarks above, Applicants submit that Ross would not have rendered claims 13, 14, 20, 21, 25 and 30-32 obvious.

II. Rejection of Claims 1, 2, 8, 9 and 26-29

Claims 1, 2, 8, 9 and 26-29 are rejected under §103(a) as being unpatentable over Gallagher in view of Ross and Angelopoulos.

Applicants respectfully submit that claims 1, 2, 8, 9 and 26-29 would not have been obvious over Gallagher in view of Ross and Angelopoulos.

Claims 1 and 26 are independent claims. Claims 2, 8 and 9 depend directly or indirectly upon claim 1. Claims 27 and 28 depend upon claim 26. Claim 29 depends upon independent claim 13.

Claims 1 and 13 were discussed above. Claim 26 is directed to a method of forming a polar liquid film on a surface of an organic film formed on a substrate in a processing vessel. The claim 26 involves a "modifying step" and an "applying step". The modifying step involves curing the organic film and imparting an affinity for the polar liquid to the organic film by irradiating the organic film with electron beams by means of an electron-beam irradiation device in a rare gas atmosphere formed in the processing vessel. The applying step involves applying the polar liquid to the surface of the organic film processed by the modifying step. The modifying step in claim 26 involves the following sub-steps:

> (i) curing the organic film entirely by irradiating the organic film with the electron beams with a first voltage applied to the electron-beam irradiation device, in the rare gas atmosphere of a first pressure in the processing vessel;
>
> (ii) further curing a surface of the organic film by irradiating the organic film with the electron beams with a second voltage lower than the first voltage applied to the electron-beam irradiation device, in the rare gas atmosphere of the first pressure in the processing vessel; and
>
> (ii) imparting the affinity for the polar liquid to the organic film by irradiating the organic film with the electron beams with the second voltage applied to the electron-beam irradiation device, in the rare gas atmosphere of a second pressure higher than the first pressure in the processing vessel.

Thus, the modifying sub-steps in claim 26 involve both pressure and voltage variations. For the reasons given previously herein, Applicants submit that the pressure and voltage variations are not mere adjustments of parameters but are used to divide the respective modifying

steps into individual effective sub-steps for their respective purposes, i.e., curing and affinity-imparting, respectively.

The Office Action acknowledges that Gallagher does not disclose the use of electron beams, that the liquid film is polar, or that the modifying step comprises curing at a first pressure and voltage and imparting affinity at a second pressure higher than the first and a second voltage. Gallagher discloses a UV-free treatment or curing step with an inert gas/oxidant atmosphere for providing a lower contact angle, i.e., higher affinity, to the dielectric film.

As pointed out above, the Office Action acknowledges that Ross does not teach the pressure and voltage variations used in the modifying sub-steps recited in the claims.

Applicants submit that because the pressure and voltage variations recited in the instant claims are not mere adjustments of parameters but are used to divide the respective modifying steps into individual effective sub-steps for their respective purposes, i.e., curing and affinity-imparting, respectively, the claims would not have been obvious over Gallagher in view of Ross. Angelopoulos is cited for its teachings regarding antireflective/hardmask compositions and does not cure the deficiencies of Gallagher and Ross relative to the pressure and voltage variations.

Thus, for at least the foregoing reasons, Applicants respectfully submit that claims 1, 2, 8, 9 and 26-29 would not have been obvious over Gallagher in view of Ross and Angelopoulos.

III. Conclusion

In view of the remarks herein, Applicants respectfully that the rejections set forth in the Office Action be withdrawn and that claims 1, 2, 8, 13, 14, 20, 21 and 25-32 be allowed.

If any additional fees under 37 C. F. R. §§ 1.16 or 1.17 are due in connection with this filing, please charge the fees to Deposit Account No. 02-4300, Order No. 033082M185.

Respectfully submitted,

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